ROUTING AND SELF-DIRECTED VEHICLE DATA COLLECTION FOR MINIMIZING DATA LOSS IN UNDERWATER NETWORK

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ABSTRACT

The underwater sensor network is now more visible due to its increased use. Furthermore, the network faces many problems and challenges due to unstable connectivity, network losses, lack of channel, lack of channel capacity, bit errors, void routing and many more. To overcome all these problems the VDSCN protocol proposes a routing system for dual route methods, they are a simple route selection and void clearance route selection. In this network, each sensor finds a forwarder and a way to transfer data. At that point, if it detects a forwarder, it begins to transfer data, otherwise, if the sensor is placed near a void, it requests sending support from a random forwarder or self-directed vehicle. To enable this, the protocol uses multiple parameter verifications so that the strong forwarder is selected and the void is detected and data collected. Thus, the network comes under stable operation.

Keywords: *Underwater Network; Dual Route Methods; Forwarder Selection; Vehicle Request; Stable transmission.*

1. Introduction

One third of the world's land area is covered by sea and water. In recent years the underwater network has become very popular due to its various applications. Among them, food search, scientific reasons and other business activities are important areas. In addition, it has important roles such as marine surveys, data collection on marine changes, disaster monitoring and marine safety monitoring. applications. Connecting countries by ship is now inevitable, as it carries a wide variety of goods around the world and also provides transportation services. For these reasons marine research has received great attention today.

The network uses a sound channel to communicate due to the high-power transmission of underwater communication. In this environment, numerous sensors are used under the sea and on the surface of the water, and to collect data collected by the sensor or by unmanned vehicles, the Sonobuoy receiver is placed on the surface of the water. The data was then transferred from Sonobuoy to a base station. Sensors face various problems due to the water environment during data transfer.

These include power loss of sensors, channel fading due to wireless nature, delays in data transfer, sensor movements, error rates, void area, and more. Yet due to the random deployment of sensors, the sensors will be less in some regions, so the path loss and noise will be higher in these areas. The routing loop occurs due to path losses, so the environment in which the packets cannot reach the destination will occur due to loop routing.

Therefore, in the proposed system, routing that detects void region before creates communications around the network is discussed. Void area sensors generate data loss, resource wastage and coverage out of range, due to this the network encounters high error rate, data loss and huge delay in routing time. This situation should be considered as the sensor has moved or rested on a void area called the local maxima. This means that there is no sensor in the area to retrieve data packets.

Sometimes the sonobuoy's sensors can go inactive quickly due to the high transmission. So, the void area can also occur. The proposed method to deal with these situations provides the solution by choosing a forward or self-directed vehicle. To finalize the forwarder or vehicle, the protocol calculates several parameters and algorithms. With all these techniques it can be seen that VDSCN has brought high performance and packet distribution rate in the output.

The paper of this research work is organized as follows. In section two, the details required to know the previous techniques are compiled. The VDSCN system was discussed and implemented in Section III. The following section describes four conclusions and discussion to demonstrate the strength of the proposed protocol. And the final section discusses the results of VDSCN and the future requirements of this study.

2. Related Works

In this protocol, only the nodes which are located inside a cone of a certain angle between the source and the destination are allowed to perform forwarding. The authors have proposed a Multi-Path Routing protocol. MPR routes packets from a source to a destination over a multi-path. A multi-path is a sequence of 2-hop sub-paths each using a different relay node for reducing data collision [5]. UWSNs are utilized for a wide range of applications such as monitoring the marine environment for scientific exploration to commercial exploitation and coastline protection to underwater pollution monitoring, from water-based disaster preventions to water-based sports facilitation [1]. Strong communication methods are essentially necessary to properly finish the communication operation between the submerged devices to make such deployments viable. Many transmission protocols were developed to address various challenges in TWSNs, making these networks a hot topic of research [7]. The method is about transmitting and getting communication under the exploitation of sound transmission in the underwater atmosphere and it is acknowledged as an acoustical or audio communication. The Underwater sensor networks comprise numerous sensors and vehicles to be organized in a particular area, to complete joint observation, and to gather the data tasks [11]. The aggregation is performed under the limits of underwater. According to these limits, the node localization is required to obtain the maximum level of connectivity between the nodes so that no node will be lost because of the absence of GPS [2]. The sensor nodes can be deployed in an adhoc manner or pre-planned manner. In an Adhoc manner, the sensor nodes are deployed randomly into the field and the network is then left unattended to perform monitoring. In a predetermined or pre-planned manner, fewer sensor nodes are placed at a particular location to monitor the environment [16-19]. A locally optimal next-hop is the neighbour closest to the sonobuoy is selected to forward the packets. It occurs when the destination is rechargeable. The node present in this region is called the void node [20-23]. If any node is stuck in this region, the packet has to discard or use some recovery technique [8]. Underwater sensor networks mainly differ in the communication media employed for information transmission. The work is given in reviews the physical fundamentals and engineering implementations for efficient information exchange via wireless communication using physical waves as the carrier among nodes in an underwater sensor network [13]. Due to higher distances and to more complex signal processing at the receivers to compensate for the attenuation of the signal, the power consumed for underwater acoustic communication is much higher than in terrestrial radio communication. Underwater sensor nodes are deployed in shallow or deep water, where it is inconvenient to charge or replace the nodes' batteries [3]. UWSN is a self-ruling sensor hubs system that is spatially allocated underwater to detect particular issues [28-32]. The stationary or mobile sensor hubs are remotely connected to exchange various occasions of intrigue through the correspondence module. It is possible to classify a large amount of UWSN applications as tracking apps [14]. A wireless sensor system is made of a huge number of sensor nodes that are thickly sent in an unattended domain. The improvements have taken in sensing innovation, low-control microcontrollers and correspondence radio have energized the large-scale manufacturing of generally economical sensor nodes [10]. Besides, some localization protocols assume a powerful node, which acts as an anchor and aids the localization process of ordinary sensor nodes by directly communicating with the surface buoys [33-37]. This is also an unrealistic assumption considering the high power consumption using acoustic modems for such long-distance [4]. The constraint most often associated with sensor network design is that sensor nodes operate with limited energy budgets. Typically, they are powered through batteries, which must be either replaced or recharged when depleted. The energy consumption of CMOS-based processors is primarily due to switching energy and leakage [12]. Wireless sensor networks have considerable potential in monitoring aquatic environments by sensing, collecting, and transferring data wirelessly to users in real-time. It has indirectly led to the emergence of a new paradigm of wireless sensor technology known as underwater wireless sensor networks [38]. UWSN technologies are implemented and deployed deep underwater with sensors using acoustic signals to perform communication [6]. Multiple unmanned or self-directed underwater vehicles, equipped with underwater sensors, will also find application in the exploration of natural undersea resources and the gathering of scientific data in collaborative monitoring missions [24-27]. To make these applications viable, there is a need to enable underwater communications among underwater devices [15]. Underwater research needs more attention due to the earth because of its majority numbers of applications. In the underwater environment, the radio frequency signalling or optical signalling cannot perform well, the source of communication in the underwater environment is only the acoustic channel [9].

3. VDSCN Design and Implementation

3.1 Network Model

The base station $B_S$on the network's ground floor and the sonobuoyS_B on the water's surface continue to broadcast their presence and location X, Y, and Z over time. The B_S announcement connects the S_Bs and self-directed underwater vehicle $S_{UV}$to the B_S, allowing them to converse directly while data is being transmitted.The sensor in the coverage range$C_R$of S_B's receives the broadcast message and rebroadcasts the message to its next stage coverage level sensors, likewise, transmitting the information to sensors all the way to the network's depth. This enables the network to be connected from the water's surface to its depth. The sensors then confirmed the distance between the S_B and itself using the position points and chose the shortest distance path to reach it at first. When the sensors reply to the S_B through a device information messageD_I, they give their location as well as the volume of energy they have. The base station gets this $D_I$message and compiles the node list, including position and energy information. The initial network was constructed in this manner, from the ground level S_B to the deep-sea level sensors.

3.2 Neighbor Apprise

All underwater sensors transmit an advertisement beacon messageA_{BM} at regular intervals to connect with surrounding sensors.This message was sent with the sensor's X, Y, and Z position coordinates.The sensors listening to this A_{BM} indicate that they are inside the range of the sensor that sent the message.Each sensor contains a list of surrounding sensors N_{BL}that is regularly updated as long as the network is operational. Each sensor will update the ID and position of the sensor that sent the A_{BM} in N_{BL} , the distance D_{ist}between those sensors is then computed as follows.

$$D_{ist} = \sqrt{|X_1 - X_2|^2 + |Y_1 - Y_2|^2 |Z_1 - Z_2|^2} . \tag{1}$$

This calculation is based on the Pythagorean theorem.Because this distance computation uses an underwater sensor network, each sensor has three coordinates: X, Y, and Z. To calculate the D_{ist}between these points, the following approach is employed, in which points (X_1, Y_1), (X_2, Y_2), and (Z_1, Z_2) are collected from two sensors location.In its N_{BL}, each sensor updates the distance between itself and its neighbor. The sensors' position points must also be updated. Following that, the sensors adjacent to each sensor will be updated on a regular basis till the end of network operation.

Similarly, the S_{UV} operating on this network has the capability of running itself, which will traverse the network, retrieve data from sensors, and transmit it to the sonobuoy. It collects data from the ocean's deep surface to the network's core. Similarly, if some underwater sensors are reported to be in the void zone, it will initially travel there and gather data from the void sensors as well as the sensors that are most prevalent in the water.

3.3 Forwarder Selection

At the start of data transmission, each sensor finds neighbors in the C_R that extends from the depths of the water to the network's surface and updates the neighbor counts based on theirD_{ist}. At the start of the network, the minimum distance neighbors will be updated. The N_{BL} will then be updated based on their movement, and a new neighbor will be chosen. They then verify the frequency of the channel $C_F$with which they are interacting.

$$S = \frac{X_1 - X_2}{C_R},\ W = \frac{Y_1 - Y_2}{C_R}. \tag{2}$$

The average distance A_D is calculated between sensors as follows:

$$A_D = \frac{D_{ist}}{C_R} \tag{3}$$

The noise levels in the channel $C_N$can vary depending on the changes that occur underwater. Here, g Is considered between (17-30).

$$T_N = \frac{g \log C_F}{10} \tag{4}$$

$$g_1 = (40 + 20)(S - 0.5) + 26 log C_F,\ g_2 = 60\log(C_F + 0.03)$$

$$O_N = \frac{g_1 - g_2}{10}$$

$$g_3 = 50 + 7.5\sqrt{w} + 20\log(C_F),\ g_4 = 40\log(C_F + 0.4)$$

$$B_N = \frac{g_3 - g_4}{10} \quad (5)$$

$$g_5 = (-15 + 20log(C_F))$$

$$U_N = \frac{g_5}{10} \quad (6)$$

These changes can be induced by changes in the temperature of the waterT_N, changes in the breeze speedB_N, changes in the uproar of the waterU_N, and even changes in the loudness of the noise caused by the movement of objects$O_N$in the water.

$$C_N = T_N + B_N + O_N + U_N \quad (7)$$

The underwater acoustic channel's depletion feature $D_F$has been observed,S_F denotes the spreading factor and sensor retention feature$R_F$is also computed. Here, m specifies 0.11, c is $1 + {C_F}^2$, a_4 is 0.001 and $k_1 = 10^{-4}$.

$$D_F = (d^{S_F})(R_F k)^{S_F} \quad (8)$$

$$a_1 = 1.70 k_1 {C_F}^2 + a_4$$

$$a_2 = \frac{m{C_F}^2}{c}$$

$$a_3 = \frac{m1{C_F}^2}{(3000 + C_F)}$$

$$R_F = a_1 + a_2 + a_3 \quad (9)$$

After identifying the $R_F$and the magnitude of the C_N, the signal's noise ratio S_{NR}should be determined using the quantity of power transmission P_T when conveying the signal with those values and the acoustic channel's capacity$C$.

$$j = \frac{P_T}{D_F}$$

$$S_{NR} = \frac{j}{CC_N}$$

We must compute the bits error rate B_{ER} generated by this noise as well as the numerous reactions that occur when the water recedes.

$$B_{ER} = \frac{1}{S_{NR}}$$

The delivery counts of packets moving through a channel under these noises, S_{NR}, B_{ER}, and D_{ist} , fluctuations should be calculated as follows. Here $P_C$is the packet counts.

$$C_{PD} = (1 - B_{ER} A_D)^{Pc} \quad (10)$$

If the C_{PD} is high, the path loss P_L in the network, as well as the predicted transmission $E_{TX}$and receiving counts $E_{RX}$of the packets delivered by the network, should be computed.

$$P_L = \frac{\sqrt{E_{FS}}}{E_{MP}}$$

Packet losses on these routes are caused by channel fading E_{FS} and many pathsE_{MP} .If this P_L is low, the E_{TX} approach described below will be computed.

$$E_{TX} = P_C \left(E_{LEC}\, E_{FS}\, D_{ist}{}^{2}\right)$$

Otherwise, the procedure described after thatE_{TX} will be calculated.

$$E_{TX} = P_C \left(E_{LEC}\, E_{FS}\, D_{ist}{}^{4}\right)$$

Similarly, reception counts E_{RX} are obtained by counting the number of receiving packets.

$$E_{RX} = P_C\, E_{LEC}$$

The network's energy expense E_E is computed as follows.

$$E_E = E_{TX} + C_R$$

Similarly, the bits sent over the network are calculated as throughput T_{pt} of the transmission. Here 8 is used to convert the packet counts into bits count.

$$T_{pt} = \frac{8P_C}{C}$$

The distance between them from source to destination is calculated when building the path required to send data as average path distance. A_{PD} .

$$A_{PD} = \frac{D_{ist} + P_D}{S}$$

If there is a void in the network during information exchange, the time interval will be determined below as V_I: Here T_T is the data transmission time.

$$V_I = (T_{Pt} + A_{PD} + T_T)1000$$

To initiate inference aware routing update distance and forwarding factor of the aspirant sensor A_S . Among the set of aspirants find a credible forwarder aspirant sensor costC_{CS} .

$$A_S = \frac{D_{ist}}{H_C N_B}$$

H_C is the number of hops in the path of the transmission.

$$H_C = \frac{D_{ist}}{C_R}$$

C_{CS} Is the credible forwarder cost computed based on the distance towards S_B and number of hops located between source to S_B. This calculation applies to all neighbor sensors in coverage.If there is no such neighbor sensor, we willdeclare the node is in the void region.

$$C_{CS} = \frac{D_{ist}}{N_B H_C} \qquad (11)$$

3.4 Void Region Elimination Process

If the sensor is in a void region, it will send a void assist announcement with its X, Y, and Z location coordinates. If any sensor or self-directed vehicle receives this notification, the distance between them will be calculated and the void node list will be updated. If a sensor hears this notification from a considerable distance away, it will rebroadcast it to it neighbors in the same coverage level.

Void detection begins when each sensor communicates in the void region. At that time each node will detect the neighbor counts within the coverage range and update the distance between them as well as update the neighbor list. If there is no forwarder at one end, find the neighbor with the shortest distance through sum distance D_S. The distance between two neighbors$Dn_1$and Dn_2 are determined here for all N_B within the C_R. Whichever sensor has the shortest distance to it will be chosen as the forwarder.

$$D_S = Dn_1 + Dn_2 < N_B$$

If there is a forwarder to the source, there is no void in that region. If there is no node forwarding to a sensor, it means it is in void region. In this situation the self-directed vehicle will be enabled to go around the void sensors to collect the data, after which it will move towards the sonobuoy and hand over the obtained data.

If multiple self-directed vehicles move around the network, then find the location points of each vehicle and find the distance A_{VD}between them along with coverage area.

$$A_{VD} = \sqrt{|A_{X1} - A_{X2}|^2 + |A_{Y1} - A_{Y2}|^2}$$

Average distance computed as below between two self-directed vehicles.

$$A_D = \frac{{A_{VD}}^2}{2}$$

Consistent communication distance C_{CD}computed for void sensor and self-directed vehicle and the coverage range computed as C_{DS}.

$$C_{DS} = {C_R}^2$$

$$C_{CD} = \sqrt{C_{DS} - A_D}$$

Time of the moving vehicle computed as T.

$$T = \frac{A_D}{S}$$

Horizontal $H$and vertical moving speed $V_M$computed within the network region for vehicles as below:

$$H = \sqrt{S_Y S_Z}$$

$$V_M = S$$

The following computations determine the distance d between the sensor and the vehicle and the S_B.

$$a = b = (X_1 - X_2)$$

$$c = Y_1 - Y_2$$

$e = (Z_1 - Z_2), g = Z_1 - Z_2$

$if\ t < \frac{H}{V_M}$ then compute below condition

$$k = abcsin(ce) + 2V_M(gV_M)$$

If this condition not satisfied compute the below distance variation step:A sensor placed in the void region will send a broadcast message asking for help, and the S_{UV} that hears it will be activated and the vehicle will start running, if the message heard by sensor it will rebroadcast to its neighbor sensors.

$$k = 2abc\sin(ce) - 2V_M(2H - gtV_M)$$

Then, compute the self-directed vehicle distance D_{AV} from void region sensor as below: Here, T_Y and T_Z are the topography Y and Z locations.

$$D_{AV} = \frac{k}{T_Y T_Z}$$

Determine the number of N_Bs in the vicinity of the S_B as neighbors N_S.

$$N_S = \frac{D_{AV}}{C_R N_B}$$

Due to the load on the sensors near the S_B, they may quickly lose their resources especially energy, this condition also causes a void area near the S_B.If so, they can call a self-propelled vehicle to collect the packets and hand them over to S_B. If NS occurs in the network area that sensor ID will be marked and sent to the S_{UV}. So, the vehicle is started and goes to that area and collects data.

To create the transmission path from the depths of the water to the S_B, the sensors select a standard contact-based routing technique by calculating the influence for the short-distance upward forwarding forwarder $I_{F,}$. If the forwarding influence is high, the sensor will act as a forwarder in the upward direction. Forwarder will remain stable until the data transfer is completed by this calculation. With this the movement of the sensor will be monitored. We also make sure that it is within the coverage of the sensor that transmits the data. This calculation avoids the connection loss caused by the loss of the forwarder connection. Here $E_{R,}$ is the remaining energy of the neighbors and $I_{E,}$ is the initial energy of them.
Find network region neighbours and sonobuoy neighbours and their location points X and Y. additionally, update the throughput, speed, remaining energy, bits per second within the coverage range.

$$Find\ N_B and\ \ N_S\ position\ X\ and\ Y$$
$$Update\ \forall\ N_B \ \rightarrow\ S, T_{pt,}, E_{R,} C_R, B_{PR}$$
$$E_{R,} = I_{E,} - E_{E,}$$
$$E = \frac{E_R}{I_E}$$
$$M = K + (1 - \alpha)E$$

Detected upward forwarder for sensor in water depth. Then the data forward from source to the destination.

$$I_{F,} = \frac{\alpha C_{CD} T_{pt,} B_{PR}}{M} \qquad (12)$$

4. Results and Discussion

This underwater sensor network is built with 100 sensors, and the size of the network is 3000 x 1000 square meters. The network uses the VDSCN protocol for routing, which, in turn, handles network-based hop-based routing and self-directed vehicle-based routing in the event of a void occurrence. Thus, many parameters are used to finalize the forwarder and route selection. The network parameters used are shown in Table .1 in the table.

Simulation Parameter	Value
Nodes	100

Topology size	3000 sqm X 1000 sqm
Sonobuoy	4
Transmission range	100 meters
Bandwidth	2 Mbps
Base Station	1
Internet Servers	1
Self-Directed Vehicle	4

Table.1 Network Parameters

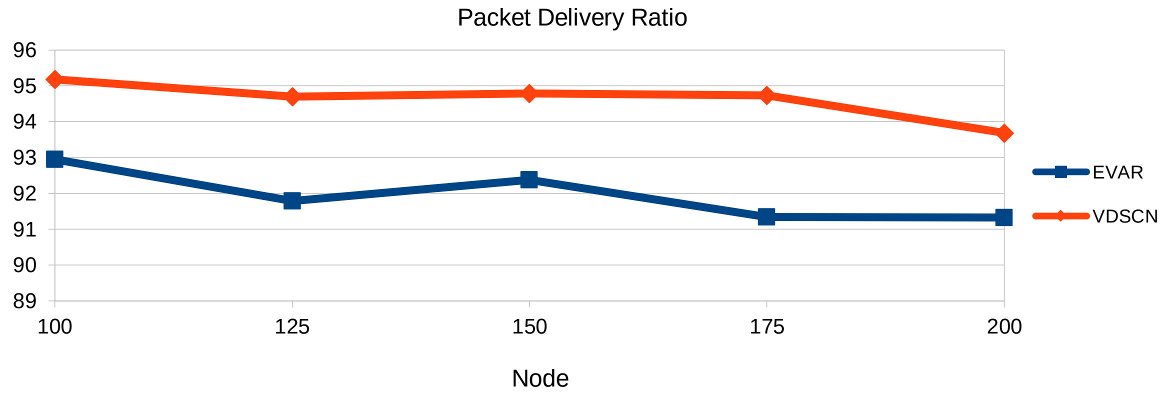

Figure.1 Node Vs Packet Delivery Ratio

Figure .1 shows the packet delivery rate PDR that occurs on the network. The PDR results between EVAR and VDSCN are built here. This shows that VDSCN is more efficient than any other network. This is achieved through validation of several parameters and standard path selection. Constant communication is established by the depth of the sensor, the distance between other sensors and the channel verifications. Based on these checks, the network selects the best forwarder to replace the packet. In addition, if the sensor moves in a void region, the self-directed vehicle goes to that area to collect data. For these reasons, PDR shows the highest performance.

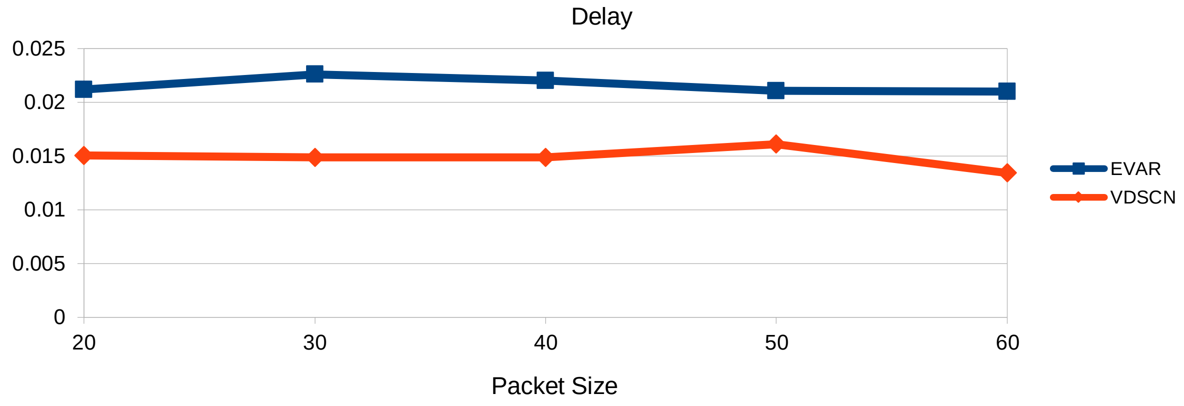

Figure.2 Packet Size Vs Delay

In an underwater sensor network, the total network delay is calculated based on the channel propagation delay, transmission interruption delay, and routing delay. Due to the lack of channel, the source packets may not reach the target in time. Similarly. Interruptions occur due to multiple transmissions in the same transmission region by various sensors, which also causes transmission delays. Similarly, the routing delay will increase depending on the hop number on the transmission path. In the VDSCN protocol, all of these issues are resolved and the necessary solutions are provided to replace the data packet. Thus, it can be seen that there is less delay of VDSCN than the existing method in Figure.2.

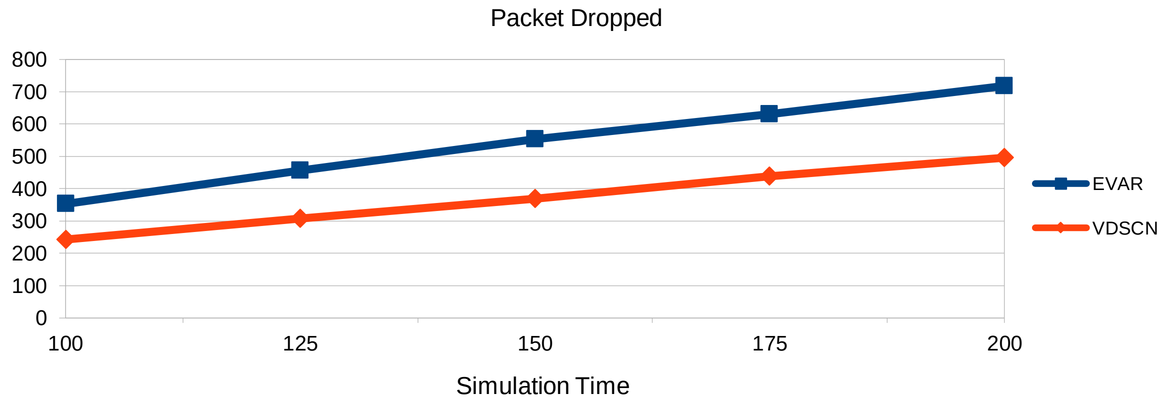

Figure.3. Simulation Time Vs Packet Dropped

Packet losses occur due to unstable forwarder selection and route creation. Forwarder selection and route selection are determined by a number of metrics in this underwater network. Furthermore, the vacuum area detected by the sensors and this situation is reported to the self-directed vehicle and other possible coverage zone sensors to collect data. Therefore, the network focuses on building a stable network until the exchange is complete. These operations create a precise transfer network, thus showing a minimal packet drop over the VDSCN protocol EVAR.

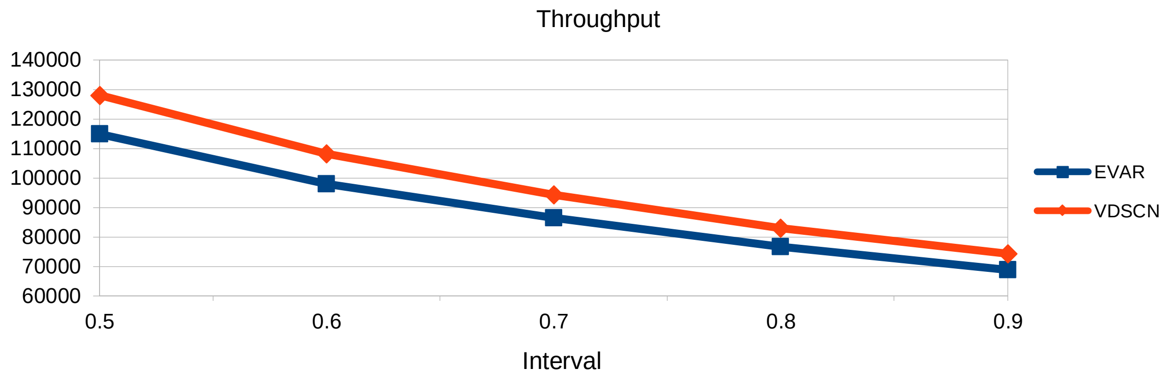

Figure.4. Interval Vs Throughput

In a network, performance is calculated on the basis of the number of packets that the source sends and the number of bits per second that the node at the destination it receives. If the network operates with minimal delay and packet drop, the target will eventually receive more packets. It reveals the quality of the network and the stability of the connection. Performance is calculated based on the number of packets received and the data duration. According to these calculations the VDSCN protocol shows higher performance than the EVAR in Figure.4.

Conclusion

Underwater sensor network has many problems during communications, of which void routing is the most important routing system. This void routing separates the network, thus causing the network to receive packet losses. If the network is normal, the VDSCN protocol handles the network normally. If the sensor is located near the void location, vacuum notifications are sent by the sensor, which communicates with the sensor or self-directed vehicle and receives the data. As long as the sensor stores the data in its local memory, if it receives a message from any forwarder, it will immediately transfer the data to the device. The VDSCN protocol uses precision methods to keep the network live and avoid route loss and delay to during transmission. Depending on the size of the network, many self-directed vehicles will travel across the network to capture data. To achieve this a number of parameters are enabled and then the network sends the data to the destination by routing. In the future, the protocol could be improved with trusted exchanges to achieve secure communications.

References

[1] Nookala Venu, S. K. (2022). Machine Learning Application for Medicine Distribution Management System. IJFANS, 11 (1), 2323-2330.

[2] Nookala Venu, S. W. (2022). A Wearable Medicines Recognition System using Deep Learning for People with Visual Impairment. IJFANS, 12 (1), 2340-2348.

[3] Dr. Nookala, Venu and Soujanya, Namoju and Goud, Burra Megamala and Bhavani, Thakur Yuktha and Rajashekar, Appidi, Study and Experimental Analysis on FBMC and OFDM (July 2022). International Journal from Innovative Engineering and Management Research (IJIEMR), Available at SSRN: https://ssrn.com/abstract=4232096.

[4] rani B, Sandhya and Katti, Sai Krishna and Ananthula, Amrutha and Dr. Nookala, Venu, Vehicle Fuel Level Monitor and Locate the Nearest Petrol Pumps Using IoT (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232110.

[5] A, Krishnaveni and Priya R, Shiva and U, Supriya and Tahseen, Anjum and Dr. Nookala, Venu, Face Mask Detection System Using Python Open CV (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232083.

[6] Dr. Nookala, Venu and M, Vamshi and V, Akhil and K, Deepika and K, Prashanth and M, Raffiudhin, Alcohol Detection and Engine Locking System (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232102.

[7] Dr. Nookala, Venu and Rakesh, Govindu and Maneesha, Kunta and Anusha, Kusumba and Merugu, Samantha and Mohammad, Abbas, Smart Road Safety and Vehicle Accidents Prevention System for Mountain Road (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232104.

[8] Dr. Nookala, Venu and Bindu, Chevulapelli and Srija, Bethi and Maheshwari, Vemula and Sarvu, Saiteja and Rohith, Sadula, Wireless Night Vision Camera on War Spying Robot (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232100.

[9] Karne, RadhaKrishna and Mounika, S. and V, KarthikKumar and Dr. Nookala, Venu, Applications of IoT on Intrusion Detection System with Deep Learning Analysis (July 2022). International Journal from Innovative Engineering and Management Research 2022, https://ssrn.com/abstract=4232107.

[10] Sandhya rani B, D. V. (2022, 07). IOT Based Smart Irrigation System Using Node MCU. IJIEMR , 100-106.

[11] Annapareddy V N Reddy. ArunKumar, N. V. (2022). On optimization efficiency of scalability and availability of cloud-based software services using scale rate limiting algorithm. Measurement: Sensors , 24, 1-13.

[12] Nookala Venu, D., Kumar, A., & Rao, M. A. S. (2022). Internet Of Things Based Pulse Oximeter For Health Monitoring System. NeuroQuantology, 20(5), 5056-5066.

[13] Nookala Venu, D., Kumar, A., & Rao, M. A. S. (2022). Botnet Attacks Detection in Internet of Things Using Machine Learning. NeuroQuantology, 20(4), 743-754.

[14] Nookala Venu, D., Kumar, A., & Rao, M. A. S. (2022). Smart Agriculture with Internet of Things and Unmanned Aerial Vehicles. NeuroQuantology, 20(6), 9904-9914.

[15] Dr. N. Venu, D. A. (2021). Comparison of Traditional Method with watershed threshold segmentation Technique. The International journal of analytical and experimental modal analysis , XIII (I), 181-187.

[16] Nookala Venu, A. S. (2018). Local mesh patterns for medical image segmentation. Asian Pacific Journal of Health Sciences, 5 (1), 123-127.

[17] Local Maximum Edge Binary Patterns for Medical Image Segmentation. International Journal of Engineering and Techniques, 4 (1), 504-509.

[18] N. Venu, "Performance and evalution of Guassian kernals for FCM algorithm with mean filtering based denoising for MRI segmentation," 2014 International Conference on Communication and Signal Processing, 2014, pp. 1680-1685, doi: 10.1109/ICCSP.2014.6950134.

[19] N. Venu and B. Anuradha, "Integration of hyperbolic tangent and Gaussian kernels for Fuzzy C-means algorithm with spatial information for MRI segmentation," 2013 Fifth International Conference on Advanced Computing (ICoAC), 2013, pp. 280-285, doi: 10.1109/ICoAC.2013.6921964.

[20] Venu, N., & Anuradha, B. (2015). Multi-Kernels Integration for FCM Algorithm for Medical Image Segmentation using Histogram Analysis. Indian Journal of Science and Technology, 8(34), 1-8.

[21] Venu, N. Design and intergration of different kernels for fuzzy means algorithm used for MRI medical image segmentation.

[22] Venu, N., & Anuradha, B. (2013). PSNR Based Fuzzy Clustering Algorithms for MRI Medical Image Segmentation. International Journal of Image Processing and Visual Communication, 2(2), 01-07.

[23] Two different multi-kernels for fuzzy C-means algorithm for medical image segmentation. Int. J. Eng. Trends Technol.(IJETT), 20, 77-82.

[24] Venu, N., & Anuradha, B. (2015). Medical Image Segmentation Using Kernal Based Fuzzy C Means Algorithm. Research Scholar, Dept. of ECE, SVU College of Engineering, Sri Venkateswara University, Tirupati-517502, India, 4(1).

[25] Venu, D., Rakesh, G., Maneesha, K., Anusha, K., Merugu, S., & Mohammad, A. (2022). Smart Road Safety and Vehicle Accidents Prevention System for Mountain Road. International Journal from Innovative Engineering and Management Research (IJIEMR).

[26] Venu, N., & Anuradha, B. (2014, February). Multi-Hyperbolic Tangent Fuzzy C-means Algorithm for MRI Segmentation. In Proceedings of International Conference on Advances in Communication, Network and Computing (CNC-2014), Elsevier (pp. 22-24).

[27] Agarwal, R. K., Sahasrabuddhe, D., & Riyajuddin, A. A Novel Dates Palm Processing and Packaging Management System based on IoT and Deep Learning Approaches.

[28] Venu, D., Arun Kumar, A., & Vaigandla, K. K. (2022). Review of Internet of Things (IoT) for Future Generation Wireless Communications. International Journal for Modern Trends in Science and Technology, 8(03), 01-08.

[29] Venu, D. N. Dr. A. ArunKumar, Karthik Kumar Vaigandla," Investigation on Internet of Things (IoT): Technologies, Challenges and Applications in Healthcare,". International Journal of Research, 11, 143-153.

[30] Vaigandla, K. K., & Venu, D. (2021). Survey on Massive MIMO: Technology, Challenges, Opportunities and Benefits.

[31] Kesavaiah, D. C., Goud, T. R., Rao, Y. S., & Venu, N. (2019). Radiation Effect To MHD Oscillatory Flow in A Channel Filled Through a Porous Medium With Heat Generation. Journal of Mathematical Control Science and Applications, 5(2).

[32] Venu, D. N. Analysis of Xtrinsic Sense MEMS Sensors. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE), ISSN, 2278-8875.

[33] Sujith, A. V. L. N., Swathi, R., Venkatasubramanian, R., Venu, N., Hemalatha, S., George, T., & Osman, S. M. (2022). Integrating nanomaterial and high-performance fuzzy-based machine learning approach for green energy conversion. Journal of Nanomaterials, 2022.

[34] Venu, N., Yuvaraj, D., Barnabas Paul Glady, J., Pattnaik, O., Singh, G., Singh, M., & Adigo, A. G. (2022). Execution of Multitarget Node Selection Scheme for Target Position Alteration Monitoring in MANET. Wireless Communications and Mobile Computing, 2022.

[35] Venu, N., Swathi, R., Sarangi, S. K., Subashini, V., Arulkumar, D., Ralhan, S., & Debtera, B. (2022). Optimization of Hello Message Broadcasting Prediction Model for Stability Analysis. Wireless Communications & Mobile Computing.

[36] Venu, N., Revanesh, M., Supriya, M., Talawar, M. B., Asha, A., Isaac, L. D., & Ferede, A. W. (2022). Energy Auditing and Broken Path Identification for Routing in Large-Scale Mobile Networks Using Machine Learning. Wireless Communications and Mobile Computing, 2022.

[37] Thouti, S., Venu, N., Rinku, D. R., Arora, A., & Rajeswaran, N. (2022). Investigation on identify the multiple issues in IoT devices using Convolutional Neural Network. Measurement: Sensors, 24, 100509.

[38] Vaigandla, K. K., & Venu, D. N. (2021). A survey on future generation wireless communications-5G: multiple access techniques, physical layer security, beamforming approach. Journal of Information and Computational Science, 11(9), 449-474.